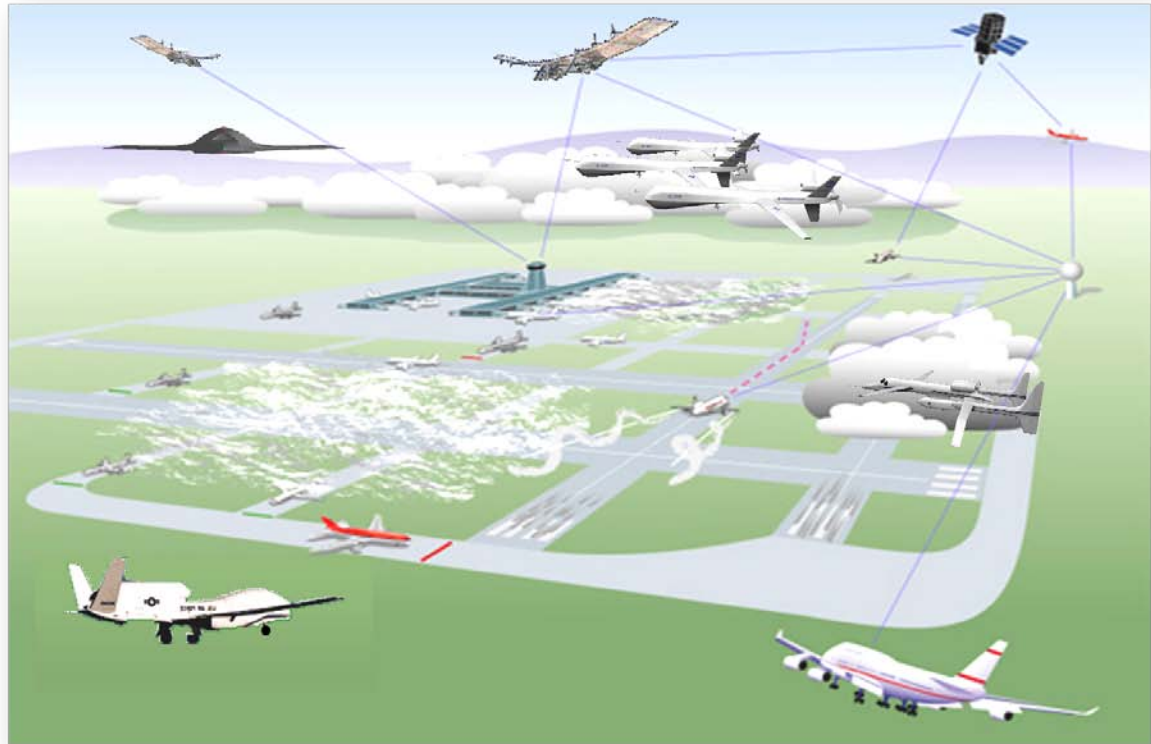


UAS Integration in the NAS Project

Project Overview



Presented by: Mr. Chuck Johnson
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TAAC
Albuquerque, NM
December 7, 2010

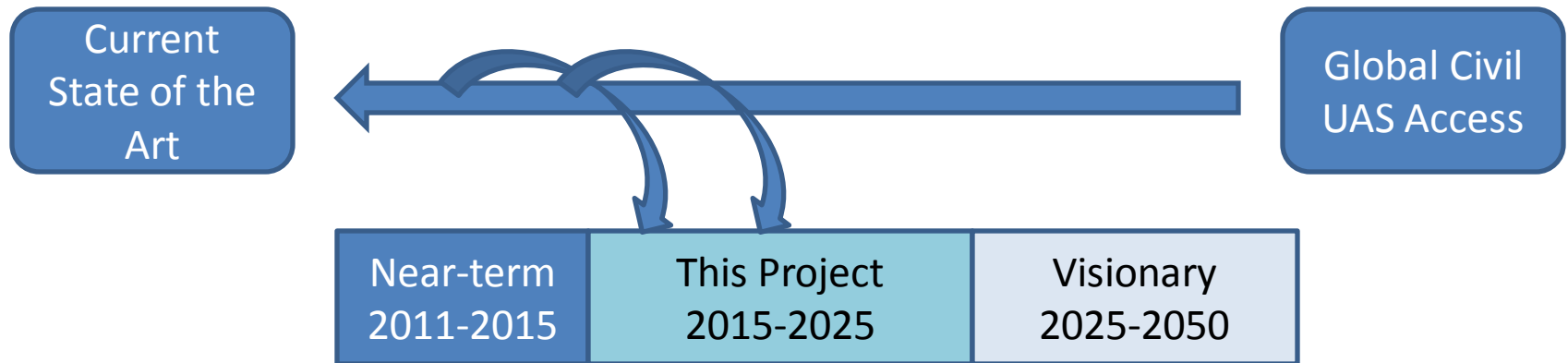
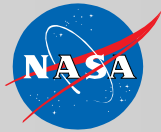
UAS Integration in the NAS Project Framework



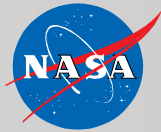
- Vision
 - A global transportation system which allows routine access for all classes of Unmanned Aircraft Systems
- Mission
 - Utilize integrated system level tests in a relevant environment to reduce technical barriers related to the safety and operational challenges of Unmanned Aircraft Systems (UAS) National Airspace System (NAS) access
 - Work with key stakeholders to define necessary deliverables/products to help enable UAS access to the NAS
- Scope
 - Technology development and demonstration in 4 specific technology elements, which will address operational/safety issues related to UAS Integration in the NAS
 - Separation Assurance
 - Human Systems Integration
 - Communications
 - Certification
 - Support the UAS Community (led by the FAA) in developing a national strategy for UAS NAS integration
 - Ensure the transfer of technology to relevant stakeholders (including the FAA, DoD, standards organizations, and industry)

The timeframe for impact will be 2015-2025

Timeline for UAS Access in to the NAS



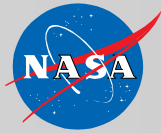
Time-Frame for Impact



Project Assumptions

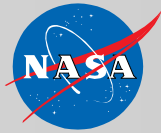
- This project will focus on civil (commercial) UAS, but will also provide substantial benefits to public (government) UAS
- Small UAS are an integrated part of the project
- Help set priorities by supporting the UAS Community (led by the FAA or JPDO) in developing a national strategy for UAS NAS integration
- We will get agreement with decision-makers that they will use the data that we generate to make decisions
- The Separation Assurance technical element will only look at collision avoidance in terms of the required interfaces (not sense and avoid algorithms)
- The Human Systems Integration technical element will use “human on the loop” level of autonomy as the baseline

Significant Stakeholders

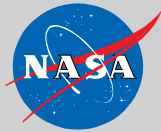


- UAS Executive Committee
 - This committee is supported at very senior levels within the FAA, DoD, DHS and NASA to address the needs of public UAS access to the NAS. NASA has a role as both a provider of technology, and a beneficiary of the outputs to enable science missions. This is not a policy-making committee.
 - Bi-weekly interactions are underway to understand issues through the Senior Steering Group, and what each agency is currently doing to address each issue.
 - Objectives: NAS Access Roadmap (Public); COA Working Group deliverables
- FAA
 - Direct interactions with relevant FAA organizations is necessary to ensure the Project understands their challenges. This will help validate the Project's course direction.
 - Numerous meetings have occurred with the FAA Unmanned Aircraft Program Office (UAPO), and the Air Traffic Organization, including the Technical Center to ensure understanding and synergy.
 - Objectives: UAS 4DT NextGen Demos; UAS Model Validation; Command/Control Communication Link model; Development and validation of algorithms; Validated NAS-wide simulations of UAS traffic impact/compatibility

Significant Stakeholders (continued)

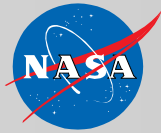


- JPDO
 - The JPDO is tasked with defining the Next Generation (NextGen) Air Transportation System. Since UAS must be incorporated into NextGen, this relationship is critical
 - Leverage already occurs with ARMD primarily through the Airspace Systems Program and Aviation Safety Program. The Project will continue to meet routinely with JPDO to synch outputs with the national strategy consistent with NextGen.
 - Objectives: UAS Integration in the NAS ConOps; Ensure UAS are include in the Integrated Work Plan
- Standards and Regulatory Organizations
 - The FAA relies on standards organizations to bring industry recommendations forward for consideration. Partnering with these organizations is essential to developing the data and technologies necessary for the FAA to approval civil UAS access.
 - Ongoing participation in committees like RTCA Special Committees, American Society for Testing & Materials (ASTM), and the World Radio Conference (WRC)
 - Objectives: Spectrum requirements; RF Compatibility/sharing studies and analyses, data and technologies to support standards work



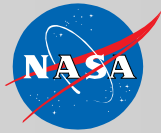
- Explore Additional Partners
 - Research and Synergies with technology development and platforms
 - AFRL
 - JCOE
 - System Users
 - Department of Justice, Department of the Interior, Department of Homeland Security
 - Commercial Entities
 - Small UAS Standards Organizations
 - American Society for Testing & Materials (ASTM)
 - Other International Standards Organizations
 - ICAO, EUROCAE, NATO
 - Etc.
- Partnership development with AFRL facilitated through upcoming JPDO/FAA/AFRL/NASA meeting
- Continue to strengthen partnerships with the FAA (UAPO, ATO UAS, and FAA Technical Center)

Where NASA will Focus



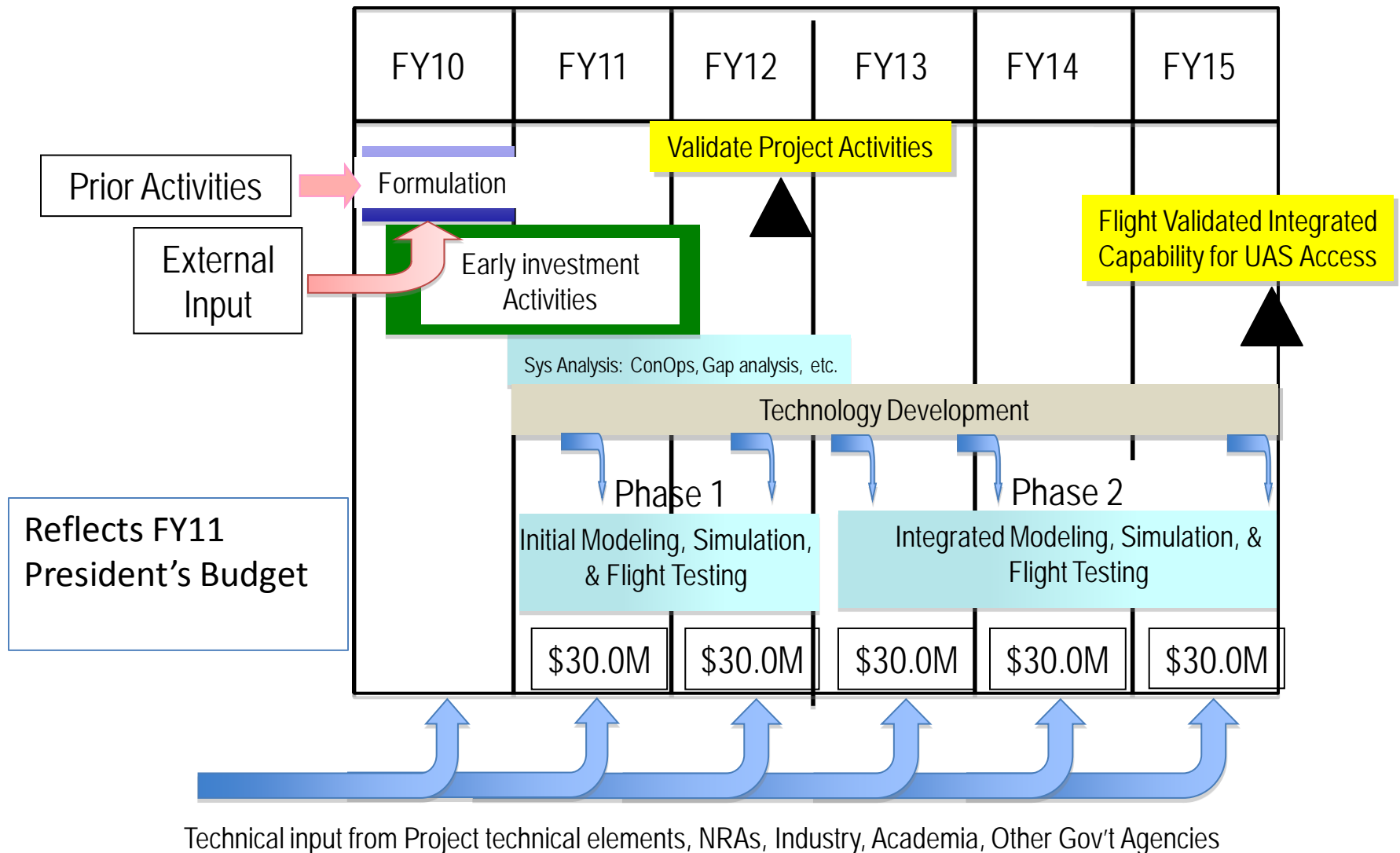
- Separation Assurance
 - Provide an assessment of how NextGen separation assurance systems with different functional allocations perform for UAS in mixed operations with manned aircraft
 - Assess the applicability to UAS and the performance of NASA NextGen separation assurance systems in flight tests with realistic latencies and trajectory uncertainty
- Human Systems Integration
 - Develop a research test-bed and database to provide data and proof of concept for GCS operations in the NAS
 - Coordinate with standards organizations to develop human factors guidelines for GCS operation in the NAS
- Communications
 - Develop data and rationale to obtain appropriate frequency spectrum allocations to enable the safe and efficient operation of UAS in the NAS
 - Develop and validate candidate UAS secure safety critical command & control (C2) system/subsystem test equipment which complies with UAS international/national frequency regulations, ICAO Standards and Recommended Practices, and FAA/RTCA Minimum Operational Performance Standards/Minimum Aviation System Performance Standards for UAS
 - Perform analysis to support recommendations for integration of safety critical C2 systems and ATC communications to ensure safe and efficient operation of UAS in the NAS

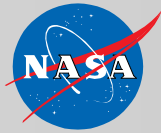
Where NASA will Focus (continued)



- Certification
 - Define a UAS classification scheme and approach to determining airworthiness requirements (FAR xx.1309) applicable to all UAS digital avionics
 - Provide hazard and risk-related data to support development of type design criteria and best development practices
- Integrated Tests and Evaluation
 - Integrate and test mature concepts from the technical elements to demonstrate and test viability
 - Evaluate the performance of the research in a relevant environment (full mission human-in-the-loop simulations and flight tests)

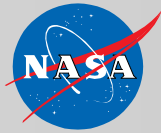
UAS Integration in the NAS Project Flow



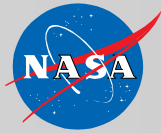


The goal of the UAS Integration in the NAS Project is to contribute capabilities that reduce technical barriers related to the safety and operational challenges associated with enabling routine UAS access to the NAS

- **Technical Plan**
 - Technical elements have been vetted with stakeholders and are complementary efforts
 - Project will employ a two-phased approach in which validation of key technical elements will be assessed in Phase 1; Phase 2 will focus on maturing and testing technical foci in relevant environments
- **Resource Allocation**
 - Project will be executed across four Centers and will leverage existing capabilities internal and external to NASA
- **Partnership Plan**
 - NASA has engaged key stakeholders in the planning of this project and will continue to do so to leverage assets of OGA's, industry and academia to execute plan

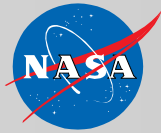


BACK-UP

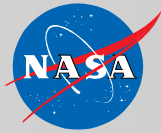


- Goal
 - Demonstrate NextGen algorithm effectiveness for UAS operations
 - Determine the efficacy of different separation assurance functional allocation paradigms for UAS in NextGen
- Objective
 - Assess the applicability to UAS and the performance of NASA NextGen separation assurance concepts in flight tests with realistic latencies and trajectory uncertainty
 - Provide an assessment of how NextGen separation assurance systems with different functional allocations perform for UAS in mixed operations with manned aircraft

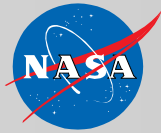
Separation Assurance Technical Challenge



- Safely and seamlessly integrate UAS into NextGen separation assurance
 - Cruise speeds, turn rates, climb/descent performance different from manned aircraft
 - Different missions than manned aircraft
 - Possible communication and control latency may drive allocation of responsibility between onboard automation and ground-based operators
 - Transitions of control between humans and automation
 - Procedural compatibility with air traffic control system

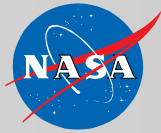


- Approach
 - Develop concepts of operations for a range of separation assurance functional allocations
 - Adapt existing NASA NextGen algorithms for UAS specific operations
 - Evaluate the architectures in fast-time and human-in-the-loop simulations
 - Obtain flight data on the algorithms/architectures performance
 - Assumptions/Constraints
 - Applicable to UAS operating in enroute airspace for which surveillance data is available
 - Assumes collision avoidance systems are developed by external partners



- Goal
 - Develop the database, by instantiating proof of concept GCS, to work with standards organizations on recommended guidelines for GCS integration in the NAS
- Objectives
 - Develop a research test-bed and database to provide data and proof of concept for GCS operations in the NAS
 - Coordinate with standards organizations to develop human factors guidelines for GCS operation in the NAS

- Database and Proof of Concept
 - Technical Challenge:
 - Display airspace information without increasing workload
 - Address UAS characteristics that make them different from manned aircraft
 - » Limited in-situ sensory input
 - Assess human-automation interaction and responsibility between onboard automation and the aircraft operator
 - Approach
 - Assess current state of GCS technology
 - Define information requirements
 - Hold a workshop to indentify relevant research and partnering opportunities
 - Modify an existing GCS for NAS integration (proof of concept)
 - ConOps for: a) large fixed-based GCS, b) small portable GCS
 - Define candidate displays & controls suite
 - Evaluate/refine in simulations
 - Demonstrate in flight



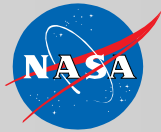
- Human Factors Guidelines

- Technical Challenge:

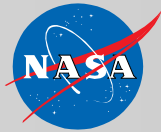
- Develop standard against which to assess UAS ground control stations
 - Current UAS GCS interfaces are aircraft specific, non-standard
 - Lack of standardized airspace information displays

- Approach

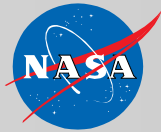
- Define scope/ issues
 - Identify on-going efforts
 - Identify appropriate standards organization
 - Develop guidelines for a initial (large, semi-autonomous) class of UAS
 - Develop guidelines for remaining classes of UAS



- Assumptions/Constraints
 - Two foci:
 - Predator-class fixed-based ground station (semi-autonomous, human-on-the-loop/supervisory control)
 - Employed by several public service agencies seeking routine access to the NAS in the 2015 timeframe
 - Small UAS portable ground station (manual control)
 - Fire, police, civil applications
 - Assess human-automation integration and function allocation
 - Address GCS human factors only as they relate to operation in the NAS
 - Apply to both civil and public UAS



- Goal
 - Validate secure scalable robust datalinks within allocated frequency spectrum for UAS
- Technical Challenge
 - Validate new UAS spectrum and data link communications to enable UAS integration in the NAS
 - Currently, UAS are managed through exceptions and are operating using DoD frequencies, amateur bands, or unlicensed Instrument/Scientific/Medical frequencies. None of these frequency bands are designated for safety and regularity of flight
 - UAS require new frequency spectrum allocations and a new data communications system which is both secure and scalable

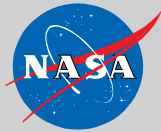


- Objectives

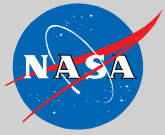
- Develop data and rationale to obtain appropriate frequency spectrum allocations to enable the safe and efficient operation of UAS in the NAS
- Develop and validate candidate UAS secure safety critical command & control (C2) system/subsystem test equipment which complies with UAS international/national frequency regulations, ICAO Standards and Recommended Practices, and FAA/RTCA Minimum Operational Performance Standards/Minimum Aviation System Performance Standards for UAS
- Perform analysis to support recommendations for integration of safety critical C2 system and ATC communications to ensure safe and efficient operation of UAS in the NAS

- Approach

- Participate and contribute to regulatory/standards organizations developing frequency, safety, security, and performance requirements for UAS safety critical C2 system. Conduct this work in partnership with other US government agencies and commercial entities within national and international spectrum/regulatory bodies.
- Design C2 system/subsystem test equipment which are compliant with these requirements through necessary technical analyses, simulations, and test measurements. Develop and test one or more C2 spectrum bands to assess performance and validate/update proposed system requirements. Validate performance during integrated testing with Human Systems Integration and Separation Assurance sub-projects.
- Perform analysis, testing, and mitigation against security risks to the confidentiality, availability, and integrity of the integrated ATC and C2 communications systems. Propose requirements and develop architectures/standards to support these requirements. Perform integrated testing to validate performance in a relevant environment.
- Develop C2 system link models for all UAS classes to predict performance during all phases of flight. Perform NAS-wide simulations of mixed traffic to determine C2 and ATC communication system performance impact on air traffic delays and system capacity. Validate performance during integrated simulations and flight testing with Human Systems Integration and Separation Assurance sub-projects.



- Assumptions/Constraints
 - Currently utilizing preliminary SC-203 & ITU-R WP5B documents for data requirements for LOS and BLOS communication to/from the UA, which estimates 80% autonomous and 20% manual in the year 2030. If all UAS were autonomous this would only decrease overall bandwidth requirements by approximately 6%.
 - This project is currently using requirements for manual operation, due to this being the worst case scenario for communication with a single unmanned aircraft
 - Small UAS will use same spectrum as other “regulated” UAS
 - This research is focused on civil applications, although public may choose to use civil spectrum and datalinks



- Goal
 - Recommend airworthiness requirements and type design criteria for UAS to facilitate safe operation in the NAS

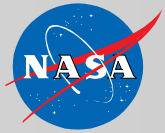
- Airworthiness Requirements
 - Technical Challenge
 - Setting suitable airworthiness requirements (FAR xx.1309 requirements) for the full range of UAS is difficult under current aircraft classification scheme
 - Objective
 - Define a UAS classification scheme and approach to determining airworthiness requirements (FAR xx.1309) applicable to all UAS digital avionics
 - Approach
 - Assess existing approaches and classification schemes, including a new service-based approach
 - Conduct comparative analysis of different methodologies
 - Work with FAA to determine best approach and conduct case study
 - Participate in regulatory/standards organizations developing UAS safety requirements

- Hazard and Risk-Related Data
 - Technical Challenge
 - Little UAS specific data (incident, accident, and reliability) exists in a civil context to support risk assessment for development of standards and regulation
 - Identify and/or develop safety-related data necessary to formulate recommendations for type design criteria and best development practices, emphasizing data for unique aspects of UAS
 - Objective
 - Provide hazard and risk-related data to support development of type design criteria and best development practices
 - Approach
 - Evaluate UAS incident/accident data collection efforts and determine additional support necessary for regulation
 - Assess UAS-specific hazards and risks and needs for additional data collection
 - Evaluate need for reliability data for UAS-unique systems, components and subsystem, and determine additional measurement requirements
 - Developing guidance and best practices for UAS type design, emphasizing small UAS design

- Assumptions/Constraints
 - Civil applicability
 - Applicability to the full range of UAS and potential UAS operations
 - Applicability to UAS with any level of autonomy
 - Working with existing regulations (FARs) and standards, to the extent possible
 - Primary focus is on airworthiness considerations for electronic aspects of UAS systems and equipment, regardless of whether they reside in the control station, on the vehicle, or are part of the command and control links
 - Some safety-related concepts (such as what constitutes an incident, an accident, hazards, and failure conditions) may be different for UAS than those for manned aircraft



- Goal
 - Integrate and test concepts, technologies, and capabilities in relevant environments that can enable UAS access to the NAS
- Objectives
 - Integrate and test mature concepts from the technical elements to demonstrate and test viability
 - Evaluate the performance of the research in a relevant environment (full mission human-in-the-loop simulations and flight tests)
- Challenges
 - Creation of an appropriate test environment
 - Integration of the technical research to probe and evaluate the concepts
 - Coordination and prioritization of facility and aircraft schedules



- Approach
 - Evaluate facilities and assets
 - Identify availability of facilities and assets (internal and external partners)
 - Guide sub-projects with selection of appropriate facilities to meet test objectives and constraints
 - Develop test procedures that span the research domain
 - Identify data acquisition systems to collect relevant data
 - Define and develop interfaces
 - Among facilities participating in a simulation
 - Between research elements and the simulation environment
 - Maintain simulation schedule
 - Use Phase 1 of the project to develop detailed test plans for Phase 2